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ABSTRACT

This study investigated achievement attitudes of young, mathematically able adolescents in order to examine differences between boys and girls equated for ability, and to explore relationships between self-perceptions, aspirations, and extra-curricular activities related to mathematics, science, or computers. The research was guided by the expectancy-value theory of achievement motivation as elaborated in a social-psychological model of academic behavior specific to the domain of mathematics. The study holds performance constant, measures persistence and choice by self-reports of plans for future studies and careers, adopts Eccles' operationalizations of individual cognitions, and adds the variable of extra-curricular mathematics, science, or computer activity as the best available indicator of socialization. Findings (based on data obtained from 242 seventh- and eighth-grade students) show no sex differences in assessments of the difficulty or usefulness of mathematics and lower expectancies for success in current and future mathematics studies reported by girls. These and other results suggest that, compared to girls, boys are obtaining more experience in applying, strengthening, and expanding school learning related to mathematics and are, in turn, bringing different entry competencies and wider perspectives to mathematics and science classrooms. (JN)

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Achievement Attitudes in Mathematics and Science: Relationships between Self-Perceptions, Aspirations, and Extra-Curricular Activities

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The comparatively limited participation of females in mathematics and science study and in occupations requiring quantitative skills has received increasing attention in recent years as women's labor force participation has grown and as leaders in government and the professions have expressed concern over the national level of tehcnological, scientific and mathematical expertise. The present research investigates achievement attitudes of young, mathematically able adolescents in order to examine differences between boys and girls equated for ability, and to explore relationships between self-perceptions, aaspirations, and extra-curricular activities related to mathematics, science, or computers. Early adolescence has been considered a crucial time for the development of sex-differentiated attitudes toward achievement in mathematics and related fields and thus a crucial time for appropriate educational intervention (Aiken, 1976; Fitzpatrick, 1978; Maccoby & Jacklin, 1974).

The research was guided by the expectancy-value theory of achievement motivation (Atkinson, 1958) as elaborated in a social-psychological model of academic behavior specific to the domain of mathematics (Parsons, Adler, Futterman, Goff, Kaczala, Meece, & Midgley, 1980; Meece, Parsons, Kaczala, Goff, & Futterman, 1982; Eccles, 1983). The model, which has been tested with schoolchildren of heterogeneous performance levels, proposes socialization factors as well as such individual cognitions as perceptions of ability, expectancies for success, assessment of task difficulty, and valuing of the task domain as among the determinants of choice, persistence, and performance in an academic field. Research on youngsters highly able in mathematics has employed somewhat different conceptualizations of those variables and has not been linked to the expectancy-value framework (Benbow & Stanley, 1982; Fox, Brody, & Tobin, 1982). The present research holds performance constant, measures persistence and choice by self-reports of plans for future study and careers, adopts Eccles' (1983) operationalizations of individual cognitions, and adds the variable of extra-curricular mathematics, science, or computer activity as the best available indicator of socialization.

METHOD

Subjects

Two hundred and forty-two students, grades seven and eight, in five public schools were studied. All students had demonstrated high performance in mathematics, which was operationally defined as a score at or above the 95th percentile on a standardized mathematics achievement test. The subject pool was the total number of seventh and eighth graders who met the criterion. More boys than girls qualified. Sex distribution of the sample was 142 boys and 100 girls, proportionately distributed by grade. All

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subjects were in mathematics honors classes. Ethnic and socioeconomic status was predominantly white, suburban and middle class.

Procedure

Four categories of variables were studied: (a) expectancy-value factors (perceptions of one's ability in mathematics, expectancies for success in mathematics, perceptions of the difficulty of mathematics, and perceptions of the usefulness of mathematics study); (b) mathematics as a male domain (perceptions of usefulness of mathematics to adult men and to adult women, and sex stereotype of mathematics ability); (c) aspirations related to mathematics and science (conceptualized as plans for the number and level of mathematics courses to be taken in high school, plans for Advanced Placement study in the physical sciences and computer science, and college major and career choice); and (d) extra-curricular activities related to mathematics and science (measured by three independent items: number of formal, out-of-school programs attended; hours per week spent in voluntary, non-program activities; and number of typical free-time activities related to mathematics and science).

Data were gathered by self-report instruments. Scales developed by Parsons et al (1980) were adapted to measure the first two sets of variables; items used in the Fox et al (1982) study of gifted children were adapted for aspirations and extra-curricular variables. For all except the last, a seven-point Likert instrument anchored at the extremes was used.

Two-way ANOVA's tested for sex and grade differences. Spearman correlations within sex were used to investigate relationships between expectancy-value perceptions and aspirations. Extra-curricular activities were explored by forming high and low participant groups within sex and using t-tests to investigate expectancy-value and aspiration differences.

RESULTS

Expectancy-Value Perceptions

Boys reported more positive self-concepts of mathematical ability on two of the three scales measuring the variable (*ability*: $F = 7.21$, $df = 1/238$, $p < .01$; *combined ability and performance*: $F = 6.50$, $df = 1/238$, $p < .01$) and on all three scales measuring the expectancy for success in mathematics variable (*current expectancy*: $F = 10.99$, $df = 1/238$, $p < .001$; *future expectancy*: $F = 12.31$, $df = 1/238$, $p < .001$; *combined expectancy*: $F = 13.69$, $df = 1/238$, $p < .001$). No sex differences were found on the usefulness of mathematics scale or on the task difficulty scales. However, grade differences were found on the latter variable with seventh graders reporting exerting more effort to do well in mathematics ($f = 6.81$, $df = 1/238$, $p < .01$), and eighth graders anticipating more difficulty with math in the future ($F = 4.12$, $df = 1/238$, $p < .05$).

Perceptions of Mathematics as a Male Domain

On a single item comparison of the mathematical abilities of boys and girls, male subjects rated the mathematical ability of their own sex higher than did female subjects who rated the sexes more nearly equal although their responses, too, were skewed in a positive direction for boys ($F = 5.23$, $df = 1/237$, $p < .05$).

When comparing adult men with adult women, both sexes regarded mathematics as more useful to adult men. In addition, girls rated mathematics more useful to adult men than did boys ($F = 4.16$, $df = 1/238$, $p < .05$).

Aspirations related to Mathematics and Science

Boys and girls did not differ in the number of years of mathematics they planned to study in high school or in their intentions to take courses in Advanced Placement mathematics, chemistry or physics. However, boys reported more definite plans to take an Advanced Placement course in computer science ($F = 23.19$, $df = 1/237$, $p < .001$) and to select mathematics or one of the physical sciences as a college major ($F = 7.37$, $df = 1/236$, $p < .01$).

An additional, open-ended question also asked students to report probable college major, and a second open-ended question asked about career interest. Chi-square analyses showed boys more likely to report mathematics or one of the physical sciences as both college and career choice ($x^2 = 7.20$, $p < .05$; $x^2 = 9.33$, $p < .01$). A further analysis found girls more likely than boys to leave unanswered these open-ended queries about future plans ($x^2 = 9.95$, $p < .01$; $x^2 = 11.06$, $p < .001$): approximately twenty-seven percent of the girls, but only ten percent of the boys gave no response.

Relationships between Expectancy-Value Perceptions and Aspirations and Mathematics as a Male Domain and Aspirations

For both sexes, ability and expectancy scales were significantly and positively related to plans for number of years of high school mathematics study and to intent to take an Advanced Placement mathematics course, with about one-third of the correlations accounting for sixteen percent of the variance or better. For boys, weaker relationships were found between ability and expectancy scales and plans for Advanced Placement chemistry or physics. For girls, weaker relationships, although significantly more positive than boys', were found between the two expectancy-value scales and plans for Advanced Placement computer science and plans for a mathematics or physical science major in college. Also, for girls, usefulness of mathematics was more strongly and consistently correlated with aspirations variables than was found for boys.

Insert Table 1 about here 5

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Relationships between mathematics as a male domain and aspirations variables were low or non-significant. Only the correlation for girls between perceptions of mathematics usefulness to adult women and intent to take Advanced Placement mathematics accounted for more than ten percent of the variance. Correlations for boys and girls were significantly different in that instance

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Insert Table 2 about here

Extra-Curricular Activities

On three independent measures, boys reported more extensive participation in extra-curricular activities related to mathematics (participation in formal programs: $F=7.97$, $df = 1/238$, $p < .005$; hours per week of voluntary math-related activities: $F = 6.82$, $df = 1/238$, $p < .01$; and number of typical activities categorized as math-related: $F = 27.50$, $df = 1/238$, $p < .001$) Activities reported and categorized as math-related were: voluntary reading on mathematics topics and doing math problems or puzzles, games of logic, computer activities, video games, and model building.

Level of Extra-Curricular Participation and Expectancy-Value and Aspiraztion Differences

To explore extra-curricular activities further, students were categorized as "high" or "low" participants for each of the three variables and t-tests were used to investigate differences on expectancy-value and aspiration variables. The analyses were conducted within sex to preclude results attributable to sex differences.

Boys. A total of nine differences in expectancy-value perceptions and twelve differences on aspiration variables were found between boys' high and low participant groups across the three extra-curricular measures. Three-quarters of these were significant at the .01 level or better. Most of the differences occurred between high and low participants in formal, extra-curricular, programs.

Insert Tables 3 & 4 about here

Girls. A total of six differences in expectancy-value perceptions and three differences on aspiration variables were found between girls' high and low participant groups. Two were significant at the .01 level. The differences tended to occur between groups high and low in number of typical activities related to math.

Insert Tables 5 & 6 about here

DISCUSSION AND RECOMMENDATIONS

This study has described achievement attitudes toward mathematics and science of highly able seventh and eighth grade students from the perspective of sex differences. It has investigated variables relating to the expectancy-value theory of achievement motivation, perceptions of mathematics as a male domain, aspirations for future study and careers, and extra-curricular activities related to mathematics.

Expectancy-Value Variables

The relatively low self-perceptions of ability and expectancies for success in mathematics found for girls parallel a large body of previous research (Crandall, 1969; Eccles, 1983; Fox et al, 1982; Maccoby & Jacklin, 1974). It would appear that, even today, among the highly able, some achievement attitudes of girls may be disadvantageous to their continued involvement in mathematics. It should be noted, however, that sex difference on expectancy-value variables, where found, were not large and should be interpreted conservatively.

In this study, girls reported lower expectancies for success in current, as well as future, mathematics study. This is a somewhat puzzling finding since the sexes were equated for math grades and test scores. It differs from the reports of Meece et al (1982) and Fox et al (1982) of lower expectancies for future activities only, and from theoretical models which propose that the lower expectancies of females are most predictable for future or novel tasks (Frieze, Fisher, Hanusa, McHugh, & Valle, 1978).

The disparate sex ratio might provide some explanation. More boys than girls qualified for the study, outnumbering girls by a three to two ratio in the honors mathematics classes. Plausibly, awareness of the disparity might influence achievement attitudes, notably the less positive ability self-concepts and success expectancies reported by girls, as well as the tendency to rate boys' mathematical abilities higher than girls' on the part of both sexes. Supporting this supposition is evidence that females in general are more responsive to social comparison cues than males, and also less likely to seek highly positive information about their abilities (see Lenney, Gold & Browning, 1983, for a review). Also, Casserly and Rock (1981) in a study of high school mathematics found that sex differences in ability comparisons occurred only in classes with the lowest ratio of females, suggesting that female confidence might be proportional to the ratio of females in class. Further research is recommended of how sex ratios in school reference groups may affect achievment attitudes.

No sex differences were found in assessments of the difficulty of mathematics, and of the usefulness of mathematics. Plans for advanced math study in high school were also equivalent. These are new findings which may reflect recent, increased awareness of the importance of mathematics generally and of its appropriateness as a subject for study by girls. Since judgments of the usefulness of mathematics has

emerged as a major predictor of plans for mathematics course enrollment, the findings provide hope that mathematically able girls, no less than boys, will continue to develop their potential at least through high school.

Will the optimistic findings counterbalance girls' less positive ability and expectancy perceptions and prevent attrition from quantitative studies at the senior high school or college level? Past studies suggest caution. In a study of Advanced Placement mathematics classes, Casserly and Rock (1981) found that only those girls with the highest quantitative aptitude were planning college majors in mathematics or science whereas measured ability among male classmates with similar goals was considerably more varied. In an attrition study at an Ivy League college , especially high measured ability was a major predictor of persistence in a mathematics or science major for women, but not for men (Ware, Steckler & Lesman, 1983). These studies suggest that female decisions to persist in mathematics and related fields are predicated on a higher level of aptitude or achievement than is true of males. Plausibly, too, highly positive self-perceptions might depend on such objective evidence of highest competence.

Aspirations

Plans for computer study in high school and college majors in quantitative fields were more strongly correlated with ability and expectancy variables for girls than for boys, again suggesting the importance of positive self-perceptions to engaging in activities generally considered more socially normative for males. Of interest, too, is the significant, positive correlation between girls' plans to take Advanced Placement mathematics and their perceptions of the usefulness of mathematics to adult women; here, it would seem, same sex adult role models serve to normalize an activity and the motivation to participate in it.

While the sexes reported equivalent plans for pre-college mathematics study, boys were more definite in their plans to take Advanced Placement computer science in high school than were girls. One might speculate that the factors promoting mathematics participation differ in quantity or quality from factors promoting computer science involvement, or, if similar, have differential effects for boys and girls. Conversations with school personnel confirmed that girls in the present study participated far less in optional computer labs than boys, a pattern of unequal female access and participation found by other researchers.

As expected, girls in the study were less likely than boys to plan college majors or careers in quantitative fields, choosing instead the biological sciences or humanities-based fields. While sex-differentiated personality characteristics or socialization to human service concerns may help explain their choices, preferences may also reflect social trends and opportunities. The substantial growth of women in

medicine, for example, has been well publicized; the participation of women in mathematics and physical sciences is numerically less, and less known. Thus, preferences of mathematically able girls for the biological sciences can be interpreted as a response to perceived gender-appropriate opportunities, and regarded in positive fashion as the selection of a field in which mathematical abilities may also be utilized.

As previously reported, significantly more girls than boys failed to respond to open-ended questions asking their plans for college study and careers. The results suggest a lack of future orientation on the part of the girls, important, according to Raynor (1974) because achievement behaviors in the present are strengthened and have greater incentive value when they are perceived as instrumental to future goals. Girls in the study had fewer mathematics-related goals and fewer goals of any sort for their post-high school future. While boys' responses may reflect self-presentational goals rather than fully-formed aspirations, it seems clear that a sex-role expectation concerning the importance of vocations has been communicated far more clearly to boys than to girls

To help maintain mathematics motivation of adolescent girls, programmatic intervention and outreach is recommended. Underlining the need is the finding that girls were less likely than boys to foresee college majors and careers in quantitative fields. Girls' positive view of the usefulness of mathematic appears to provide a basis for school intervention. Instruction and experiences inthe application of mathematics to a wide variety of occupations, including human service occupations, is recommended.

Extra-Curricular Participation

Extra-curricular mathematics participation was viewed as the best availabnle indicator of socialization in the study; results in the direction of boys were found, as expected. The analyses within sex found differences on expectancy-value and aspiration variables between high and low participant boys, but a less clear-cut pattern for high and low participant girls. Also, boys who are high participants (by same sex standards) have more definite plans for mathematics-related study and careers than do girls who are high participants(by same sex standards). The analyses appear to suggest that extra-curricular math-related participation has different meanings to boys and to girls, being for, boys, a more integral part of other life activities and associated with different components of the expectancy-value theory.

In addition, out-of-school participation may mean that boys are bringing different entry competencies and expanded perspectives to the math and science classroom. Sherman (1978) and Linn and Peterson (1984) believe that boys' and girls' differential engagement in activities associated with kinesthetic cues may provide practice in spatial skills important in some aspects of mathematics. Fox (1977) suggests that some of the sex differences in mathematics scores of gifted children may be due to differential

exposure to out-of-school math activities since even the most mathematically gifted girls are "markedly different from the mathematically gifted boys in their willingness to study mathematics ...outside of school" (p 304). In a pioneering empirical study of extra-curricular learning from the perspective of sex differences, Steinkamp and Maehr (1984) differentiated motivational orientations of boys and girls according to whether science subjects are school-based or learned informally through extra-curricular activities and contacts. According to their analysis, girls' motivations surpass boys' in subjects that are school-based, such as biology, whereas boys' motivational orientations surpass girls' in subjects such as physics that boys, but not girls, tend to learn in out-of-school settings which afford opportunities for informal enjoyment and the development of positive attitudes.

Out-of-school mathematics participation may have other important consequences. It may help with the process of socialization into a field, as youngsters acquire more knowledge of topics of study or work, exchange ideas, and measure themselves again domain demands. Real-life applications may be observed and practiced. The extra-curricular activities may also serve as a corrective to possible limiting or unrealistic in-school factors. Walberg (1969) has pointed out that the docile, conformist behavior often rewarded in elementary school may be maintained by older girls even though it is dysfunctional for inquiry and work in the sciences. Callahan (1979) points out that bright, well-behaved girls may be rewarded with good grades and are likely to associate grades with good behavior and with success. Lacking the corrective of an outside perspective, such girls may develop unrealistic views of the process of achievement in other educational settings and in the adult world.

The present study suggests that, compared to girls, boys are obtaining more experience in applying, strengthening, and expanding school learning related to mathematics and are, in turn, bringing different entry competencies and wider perspectives to the math and science classroom. Large scale, empirical studies are needed of the possibly reciprocal influences of extra-curricular activities and school achievement.

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Table 1

Correlation Coefficients of Expectancy-Value and Aspirations Variables
(N of Boys = 142, N of Girls = 100) [a]

Attitude	Yrs of Opt Math Study	A. P. Math	A. P. Chem/Phys	A. P. Comp Sci	Math/Ph Sci College Maj
Ability	.25***	.37***	.25***	.002	.13
	.33***	.39***	.04	.35***	.38***
Performance	.23**	.34***	.21**	.08	.06
	.33***	.30***	.14	.21**	.20*
Combined Ability & Performance	.28***	.40***	.26***	.04	.12
	.41***	.39***	.10	.30***	.36***
Current Expectancy	.31***	.40***	.21**	.07	.02
	.33***	.31***	.08	.30***	.30***
Future Expectancy	.38***	.52***	.25***	.13	.22**
	.28**	.45***	.23**	.33***	.35***
Combined Expect'cy	.38***	.49***	.24**	.11	.14*
	.34***	.44***	.19*	.37***	.38***
Current Difficulty	-.23**	-.25***	-.18*	-.01	.07
	-.30**	-.11	.08	-.22**	-.23**
Future Difficulty	-.21**	-.23**	-.14*	-.04	.12
	-.25**	-.22**	.05	-.25**	-.15
Combined Diff'ty	-.23**	-.26***	-.17	-.02	.09
	-.31***	-.17*	.07	-.26**	-.27**
Required Effort	-.08	-.05	.11	-.07	.03
	-.15	-.13	.09	-.21*	.08
Actual Effort	.05	.13	.24**	-.07	-.09
	.01	.05	.12	.08	-.11
Usefulness	.37***	.27***	.12	.19**	.46***
	.33***	.60***	.47***	.31***	.46***

a. Upper figures are correlations for boys, lower figures for girls. Boxed sets indicate significantly different correlations.
* $p < .05$ ** $p < .01$ *** $p < .001$

Table 2

Correlation Coefficients of Perceptions of Mathematics as a Male Domain and Aspirations Variables

(N of Boys = 142. N of Girls = 100)[a]

Attitude	Yrs of Opt Math Study	A. P. Math	A. P. Chem/Phys	A. P. Comp Sci	Math/Ph Sci College Maj
Math Usefulness to Adult, Women	.13 .29**	.07 .33***	-.01 .20*	-.01 .12	.19** .21*
Math Usefulness to Adult Men	.18** .20*	.13 .21	.04 .10	.10 .05	.29*** .17*
Sex Stereotyping of Math Ability	-.07 .03	-.08 .02	-.05 -.03	-.09 -.16*	-.11 -.05

a. Upper figures are correlations for boys, lower for girls. Boxed sets indicate significantly different correlations.

* p < .05 ** p < .01 *** p < .001

Table 3

Expectancy-Value Differences between Boys' High and Low Extra-Curricular Participation Groups (N = 142)

Activity Attitude Scale / Participation	N	Mean	S.D.	t	p
Formal Programs					
Ability				2.38	.02
Low	82	15.23	3.17		
High	60	16.45	2.78		
Performance				3.73	.001
Low	82	16.25	3.10		
High	60	17.90	2.19		
Ability & Performance				3.47	.001
Low	82	31.47	5.59		
High	60	34.35	4.28		
Current Expectancy				2.67	.01
Low	82	16.43	3.02		
High	60	17.73	2.66		
Future Expectancy				4.15	.001
Low	82	16.27	3.45		
High	60	18.18	2.01		
Combined Expectancy				3.70	.001
Low	82	32.69	5.98		
High	60	35.92	4.39		
Current Difficulty				2.04	.04
Low	82	15.69	4.79		
High	60	14.07	4.55		
Free-Time Math Activities					
Use				2.26	.02
Low	83	16.06	4.85		
High	59	17.86	4.42		
Typical Activities Related to Math					
Use				2.72	.01
Low	72	15.76	4.91		
High	70	17.88	4.34		

Table 4

Aspiration Differences between Boys' High and Low Extra- Curricular Participation Groups (N = 142)

Activity Plan	Participation	N	Mean	S.D.	t	p
Formal Programs						
AP Math in HS					3.87	.001
	Low	82	4.72	1.60		
	High	60	5.68	1.25		
AP Chem/Physics in HS					2.35	.02
	Low	82	4.54	1.60		
	High	60	5.17	1.54		
AP Computer Science in HS					3.55	.001
	Low	82	4.78	1.73		
	High	60	5.73	1.35		
College Maj in Math/Phy Sci					2.47	.01
	Low	82	4.44	1.74		
	High	60	5.12	1.37		
Free-Time Math Activities						
AP Computer Science in HS					2.44	.01
	Low	83	4.90	1.63		
	High	59	5.58	1.60		
College Maj in Math/Phy Sci					3.00	.003
	Low	83	4.39	1.67		
	High	59	5.21	1.42		
Typical Activities Related to Math						
AP Math in HS					2.00	.04
	Low	72	4.87	1.56		
	High	70	5.38	1.47		
AP Computer Science in HS					3.07	.003
	Low	83	4.78	1.63		
	High	59	5.60	1.56		
Coll Maj in Math/Phys Sci					2.44	.01
	Low	83	4.40	1.63		
	High	59	5.06	1.55		

Table 5

Expectancy-Value Differences between Girls' High and Low Extra-Curricular Participation Groups (N = 100)

Activity Plan	Participation	N	Mean	S.D.	t	p
Formal Programs Use					2.07	.04
	Low	76	15.38	4.77		
	High	24	17.70	4.85		
Free-Time Math Activities Performance					2.18	.04
	Low	54	15.76	2.59		
	High	46	16.81	2.73		
Typical Activities Related to Math Performance					2.08	.04
	Low	59	15.81	2.64		
	High	41	16.93	2.62		
Ability & Performance					2.09	.04
	Low	59	30.00	5.38		
	High	41	32.21	4.98		
Current Difficulty					2.73	.008
	Low	59	16.32	3.91		
	High	41	13.90	4.95		
Combined Difficulty					2.44	.02
	Low	59	31.51	6.12		
	High	41	28.15	7.65		

Table 6

Aspiration Differences between Girls' High and Low Extra-Curricular Participation Groups (N = 100)

Activity Plan / Participation	N	Mean	S.D.	t	p
Formal Programs					
Years of Optional Math				2.49	.01
Low	76	5.39	1.45		
High	24	6.00	.88		
Free-Time Math Activities					
AP Math in HS				2.08	.04
Low	54	4.88	1.35		
High	46	5.53	1.50		
Typical Activities Related to Math					
Years of Optional Math				2.42	.02
Low	59	5.29	1.50		
High	41	5.90	1.00		